CALFED BAY-DELTA PROGRAM

Office Memorandum

Date: August 21, 1998

To: Dave Samson

From: Paul Massera

Subject: Summary of Delta Simulation Modeling Studies

Per your request, a report has been prepared that summarizes the Delta simulation studies that have been performed to date by DWR Modeling Support Section and CALFED. It is intended to provide a brief and concise document that highlights the most significant assumptions and results of the modeling efforts with respect to the CALFED alternatives. Specifically, this report summarizes the principle methodologies and results of the studies:

- Status Reports on Technical Studies for the Storage and Conveyance Refinement Process dated March 20, 1997
- Delta simulation Model Studies of Alternatives 1A, 1C, 2B, 2D, 2E, and 3E dated August 4, 1998
- Delta simulation Model Studies of Alternatives 1A, 1C, 2B, 3E and 3X dated January 16, 1998
- Delta simulation Model Studies of Alternatives 1C, 2B, and 3X dated June 1, 1998

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SUMMARY OF DELTA SIMULATION MODEL STUDIES TO DATE

August 1998

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CALFED BAY-DELTA PROGRAM
SUMMARY OF DELTA SIMULATION STUDIES TO DATE

TABLE OF CONTENTS

INTRODUCTION

CALFED and DWR Modeling Support Branch have undertaken modeling activities in an attempt to simulate existing conditions as well as implementation of various components of the CALFED Alternatives with respect to the Bay-Delta. The goal is to develop fair and reasonable operating concepts in conjunction with proposed storage and conveyance facilities. Operating concepts are critical as they largely determine what resources will benefit from new facilities. The Delta Simulation Models (DSM1 and DSM2) are effective tools that facilitate exploration of the interactions of storage and conveyance alternatives. DSM2 is a model of river, estuary, and land processes that are combined in a package of three main modules: hydrodynamics (Hydro), water quality (Qual), and particle tracking (PTM). Key components of DSM are storage, diversions, releases, and allocation of water in the system. DSM results include: flows and velocities, circulation patterns, salinity (TDS and X2), and water levels. This memorandum summarizes the progress to date on CALFED-related Delta simulation modeling studies. The studies are presented in the chronological order.

The initial study dated March 1997 utilizes DWRDSM1 and simulates five alternatives including: Existing Delta Geometry, Interim South Delta Program, North Delta Program, North Delta Program with Hood Diversion and CUWA alternative C geometry. Similarly, the next study dated August 1997 utilizes DWRDSM1 to simulate CALFED alternatives 1A, 1C, 2B, 2D, and 3E. The January 1998 study utilizes DWRDSM2 to simulate CALFED alternatives 1A, 1C, 2B, 3E, and 3X. Lastly, the June 1998 study also utilizes DWRDSM2 to simulate CALFED alternatives 1C, 2B, and 3X. The difference between the January and June studies, however, is a variation in the DWRSIM studies that were incorporated into the simulations. Details regarding each of these studies are summarized in subsequent sections of this report.

SUMMARY OF PROGRESS TO DATE

Summary of March 1997 Delta Modeling Progress Report

Background:

DSM1 was used to simulate five CALFED Alternatives. The five alternatives include: Existing Delta Geometry, Interim South Delta Program (ISDP) geometry, North Delta Program (NDP) geometry, North Delta Program with Hood Diversion geometry (NDPH), and CUWA Alternative C geometry (CUWA – C).

The hydrodynamic and tracking results of the preliminary DSM1 runs are presented in this report. Two strategies were employed in this analysis. One method averages the results of modeling daily Delta inflows and exports and historic boundary tide from a May hydrology. The second method models a single 25-hour period using average Delta inflows and exports from the same May hydrology with the 19-year mean tide.

Delta boundary conditions included the following:

- Inflows and exports were derived from the historic period of April through May of 1989. Flows were adjusted to reflect how the SWP/CVP might have been operated over this period to meet the SWRCB 1995 Water Quality Control Plan.
- Sacramento inflow varied from 40,000 cfs (April) to 10,000 cfs (May).
- CVP/SWP pumping ranged from 2,000 cfs to 10,000 cfs.
- Boundary tide at Martinez was historical tide during April and May 1989.

Results:

Results are presented with respect to ISDP unless otherwise specified.

(1) Existing Geometry and ISDP Geometry

(A) Hydrodynamics -- ISDP alternative had little impact on flows and velocities in the Sacramento River and the north Delta. Operation of the Middle River and Old River flow control structures caused more San Joaquin River water to flow downstream of the head of Old River. The ISDP permanent flow control structures raised minimum water levels and promoted greater circulation than the temporary structures (Existing Geometry).

(B) Mass Tracking – Mass tracking results showed no significant differences between the existing geometry and ISDP geometry. Both scenarios assumed a complete closure of the head of Old River.

(2) **North Delta Program Geometry**

(A) Hydrodynamics – NDP substantially increased flow in the DCC. Likewise, flows were increased down the Mokelumne River into the San Joaquin River and down Little Potato Slough. Average flow in the San Joaquin was substantially increased while average flow in the Sacramento River was decreased. Average velocities increased and decreased similar to flow. Flows, velocities, and stages in the south Delta didn't significantly change between NDP and ISDP alternatives.

(B) Mass Tracking – NDP showed little difference from the ISDP alternative after 15 or 30 days when injected at Vernalis.

(3) **North Delta Program with Hood Diversion**

(A) Hydrodynamics – Despite the 5,000 cfs diversion; flows, velocities, and water levels were much the same as the NDP program. Exceptions include: flow and velocities in the DCC, Georgiana Slough, and Mokelumne River.

(B) Mass Tracking – NDPH showed little difference from the NDP alternative.

(4) **CUWA – Alternative C**

(A) Hydrodynamics – A large increase in cross-Delta flow through Tyler Island was experienced as well as much lower velocities through the North Delta. Minimum water levels increased in the south Delta.

(B) Mass Tracking – More mass remained in the Delta for each injection site. When injected at Columbia Cut, less mass ended up at the SWP and CVP pumps.

Summary of August 1997 Delta Modeling Progress Report

Background:

DWRDSM1 was used to perform simulations of six CALFED Alternatives. Detailed results of these simulations are presented in the report entitled *Delta Simulation Model Studies of Alternatives 1A, 1C, 2B, 2D, 2E, and 3E* dated August 4, 1997. These alternatives were chosen to represent a range of possible impacts in the Delta. Modeling parameters include: flow and velocities, circulation patterns, salinity (TDS and X2), and water levels in the south Delta. Boundaries for modeling the Delta are the Sacramento River at I Street, San Joaquin River at Vernalis, and Carquinez Strait at Martinez.

Boundary conditions include the following:

- The 16-year hydrology from DWRSIM study 472B (1976-1991) was used to simulate each alternative.
- The study assumed that the SWRCB 1995 WQCP was followed.
- South Delta Improvements enabled Banks to export at a rate of 10,300 cfs.
- 2020 level of demand
- 19-year mean tide was used at Martinez.
- Salinity of Sacramento River and Yolo bypass inflows was kept at a constant 100 ppm.
- Delta Channel depletions were obtained from DWR's DICU model.

Operating assumptions include the following:

- The DCC was operated according to SWCB 1995 WQCP. However, if the Sacramento inflows exceeded 25,000 cfs the DCC was closed.
- CCFB was operated under priority 3 or priority 4. Priority 3 provides some protection for minimum water levels in the Delta channels but may diversions into the forebay.

- Suisun Marsh Salinity Control gates were operated from October through May in critical, dry, and below normal years.
- Alternatives 1C and 2B assumed that permanent flow control structures on the Old River, Middle River, and GLC operated during the irrigation season.
- For 2B and 2D, Hood Pumping Plant diversion matched Banks and Tracy pumping rates up to 10,000 cfs.
- For 3E, the Hood diversion provided 15,000 cfs for the IF. The diversion rate matched Banks and Tracy exports.

Results:

(1) Flows

Improvements in the south Delta appeared to have little effect on cross-Delta flow. The cross-Delta flow for Alternative 2B was slightly higher than that of Alternative 2D. This indicates that improvements in the North Fork of the Mokelumne River produced the same effects on cross-Delta flow as did South Fork improvements. Cross-Delta flow under Alternative 2E was the highest due to the flooding of Tyler Island. Alternative 3E drew most of the CVP/SWP water from the Sacramento River through the isolated facility. This alternative has the lowest cross-Delta flow.

QWEST is a function of cross-Delta and CVP/SWP pumping rates. Alternatives 1A and 1B resulted in the lowest QWEST flows. Low cross-Delta flows in Alternative 3E seemed to balance with the low demand towards the pumps resulting in similar QWEST values as alternatives 2B and 2D.

(2) Salinity

At **Jersey Point** alternatives 1A and 1C had no impact of salinity. Conversely, alternatives 2B, 2D, 2E, and 3E reduced salinity particularly during the first and the last quarter of the water year – when water was less abundant. This occurred due to improved cross-Delta flow to the

San Joaquin River system toward Jersey Point. During the middle part of the year when more water was available in the Delta, salinity was not affected. Antioch showed a similar trend as in Jersey Point.

The same alternatives that reduced Jersey Point salinity increased salinity at **Emmaton**. This is due to the increase in cross-Delta flows from 2B, 2D, 2E, and 3E. As expected, less freshwater from the Sacramento River at Emmaton due to diversion to Jersey Point through cross-Delta flow. During wet seasons all alternatives had very little impacts on Emmaton salinity.

Salinity at **CCFB** was greatly improved during less abundant water seasons under all alternatives except 1C. While salinity in Old and Middle Rivers were unaffected by the alternatives except for October, November, April, and May when alternatives 2D, 2E, and 3E showed slight impacts. During October these alternatives had adverse impacts on salinity in these rivers. Conversely, in November salinity was reduced in Old and Middle Rivers.

Generally, alternatives had very little impact on **X2**. Furthermore, alternative 1C had no impact. For alternatives 2B, 2D, 2E, and 3E X2 moved slightly landward during the first and last quarter of the water year. During the wet season however, the position was shifted slightly seaward for these alternatives.

(3) South Delta Water Levels

The **Middle River** flow control structure was operated from April – September. As such, water levels upstream of the structure in alternatives 1C and 2B were more than 18 inches higher than downstream of the structure. Water levels for alternatives 2B, 2D, 2E, and 3E were higher (downstream of the structure) than that of 1C and 2B. In other words, water levels would rise for alternatives 2B, 2D, 2E, and 3E even without the structure.

The flow control structure at **Old River** was operated during the same period as Middle River. In alternatives 1C and 2B water levels increased by 12 inches – 20 inches. Alternatives 2D and 2E increased water levels more than 6 inches over alternative 1A.

The **Grant Line Canal** flow control structure was operated from June through September. Alternatives 1C and 2B showed a substantial increase in water levels. An increase in water levels was shown in alternatives 2D, 2E, and 3E even without the structure.

Summary of January 1998 Delta Modeling Progress Report

Background:

This progress report summarizes the results of DSM2 runs performed for Alternatives 1A, 1C, 2B, 3E, and 3X. Detailed results of these simulations are presented in the status report entitled *Delta Simulation Model Studies of Alternatives 1A, 1C, 2B,3E, and 3X* dated January 1998. These runs used the following DWRSIM Delta hydrologies: 516, 531, 532, 551, and 567, respectively. Delta hydrodynamics and electrical conductivity were simulated for each Alternative. The same boundary conditions and assumptions were used in this study as is described in the June 1998 report.
Delta boundary conditions included the following:

- The 19-year tide at Martinez is used to generate the Delta tidal action contributing to Delta hydrodynamics and water quality. This 25-hour sequence is repeated throughout the 16-year simulation period.
- All studies assumed a 2020 level of development.
- Salinity at Martinez was calculated using ANN. This model derives EC as a function of outflow.
- The CCFB intake gates are operated monthly under priority 2, 3, or 4. Priority 2 is the most protective of water levels while priority 4 is the least. Typically, the alternatives that include a CVP-CCFB intertie needed to be operated under priority 4 due to greater demands on the forebay from both projects.
- Flow control structures in Grant Line Canal, Old River, and Middle River are installed and operated for Alternatives 1C, 2B, and 3X.
- Fish control structure at the head Old River is assumed installed for Alternatives 1C, 2B, and 3X.

Results:

(1) Flows

Alternatives 1A and 1C have similar trends and magnitude as does Alternatives 3E and 3X. Alternative 2B tends to have the greatest cross Delta flow and Alternatives 3E and 3X have the least. Cross Delta flow for Alternatives 1A and 1C consists of total flow in the DCC and Georgiana Slough.

Alternatives 2B, 3E, and 3X significantly increase QWEST flows over Alternatives 1A and 1C. These increases often result in QWEST changing from negative to positive values (reversal of flows) when compared to Alternatives 1A and 1C. Alternative 2B significantly increases flows at QWEST by increasing DCC flows. Alternatives 3E and 3X significantly increased QWEST flows by reducing south Delta exports compared to 1A and 1C. The key component that is common to these three alternatives is the increased capacity of the north fork of the Mokulmne River.

(2) Water Levels

Alternatives 1C, 2B, and 3X included south Delta flow control structures in the Middle River, Grant Line Canal, and Old River near the DMC intake. All alternatives except 1A operate with a fish control structure at the Head of Old River in the spring and fall. Minimum water levels in the Middle River increase about 2 feet with the flow control structures installed. This applied to all alternatives. Alternative 3E, with little south Delta diversions and no structures, slightly increases the minimum water levels in Middle River.

Similarly, water levels in Grant Line Canal and Old River (upstream of DMC) increase for the alternatives with the flow control structures. The increase in minimum levels are 0.25-foot to 1-foot in April through May and about 2 feet in June through September when Grant Line Canal flow control structure begins to operate. Grant Line Canal and

Old River need GLC structure to operate before levels begin to match those in the Middle River. Water levels under Alternative 3E increase in GLC and Old River about 0.2 feet to 0.5 feet.

(3) Electrical Conductivity

At **Jersey Point** (Figure #), Alternatives 2B, 3E, and 3X significantly reduce EC when compared to Alternatives 1A and 1C. EC values under Alternative 3X fall between those under Alternatives 1C and 3E.

In the **south Delta** EC in Old River tends to decrease under Alternatives 1C, 2B, and 3X (compared to that of Alternative 1A). This is due to improved circulation patterns created by the operation of the flow control structures. Alternative 3E tends to increase EC compared to that of Alternative 1A.

EC in **CCFB** is significantly lower under Alternatives 2B, 3E, and 3X than under Alternatives 1A and 1C. Alternatives 2B, 3E, and 3X provide more Sacramento River water with less mixing with Delta channel water prior to discharge into CCFB. Under Alternatives 3E and 3X, nearly all of the forebay water comes from the Sacramento River (Hood) in April and June.

(4) X2 Location[1]

The definition of X2 is as follows: The distance upstream of Golden Gate where a salinity concentration of 2 parts per thousand occurs. X2 may vary between the alternatives for two reasons: differences in outflow and differences in QWEST (when X2 begins to near Collinsville). Alternative 3E tends to cause the lowest X2 values while

[1] The significance of this occurrence is believed to be related to food abundance, birth/mortality rates, and habitat impacts. X2 has been linked to the abundance of Longfin Smelt and Pacific Herring (but not Delta Smelt). It has also been linked to the survival index of Striped Bass. Essentially, X2 is thought to be the threshold between riverine flows and estuarine flows. It is largely believed that the farther west that X2 is located, better habitat and survivability conditions exist for the aquatic life.

Alternative 2B at times causes the highest values. Typically, when Delta outflow is relatively high (winter and spring) there is little difference in X2 between the alternatives. However, in late summer and fall when X2 is higher, differences become larger.

Summary of June 1998 Delta Modeling Progress Report

Background:

Delta modeling studies have been completed for CALFED alternatives 1C, 2B, and 3X using DWRDSM2. The results of these simulations are presented in the status report entitled *Delta Simulation Model Studies of Alternatives 1C, 2B, and 3X* dated June 1998. These simulations differ from those detailed in the January 1998 report in that different DWRSIM studies were used. Specifically, DWRSIM study 532a was used for alternatives 1C and 2B. Similarly, study 636 was used for alternative 3X. The DWRSIM studies used in this report include an assumption of zero trigger for Sacramento River flow for NDSS and NDES diversions.

Results:

(1) Flows

No significant flow variations were evident as a result of the variation in DWRSIM studies used for alternative 1C simulations (See January 1998 Study Update section). For alternative 2B, significant decreases in cross Delta flows as well as a reduction in flows in the Mokelumne River at Andrus Island were experienced. Similarly, a slight decrease in North Mokelumne River flows occurred.

(2) Water Levels

No significant water level variations were evident as a result of the variation in DWRSIM studies used for the three respective simulations.

(3) Electrical Conductivity

As expected, EC is slightly higher at Clifton Court Forebay, Contra Costa Canal Intake, and DMC intake for al three alternatives.

(4) X2 Location

No significant changes in X2 were evident

REFERENCES

California Department of Water Resources, Delta Modeling Section, March 1997, *Status Report on Storage and Conveyance Refinement Process*

California Department of Water Resources, Delta Modeling Section, August 1997, *Delta Simulation Model Studies of Alternatives 1A, 1C, 2B, 2D, 2E, and 3E*

California Department of Water Resources, Delta Modeling Section, January 1998, *Delta Simulation Model Studies of Alternatives 1C, 2B, 3E, and 3X*

California Department of Water Resources, Delta Modeling Section, June 1998, *Delta Simulation Model Studies of Alternatives 1C, 2B, and 3X*

California Department of Water Resources, Division of Planning, Multiple Reports (February 1990, April 1991, June 1992, June 1993, June 1997), *Methodology For Flow and Salinity Estimates in the Sacramento – San Joaquin Delta and Suisun Marsh*